National Aeronautics and Space Administration

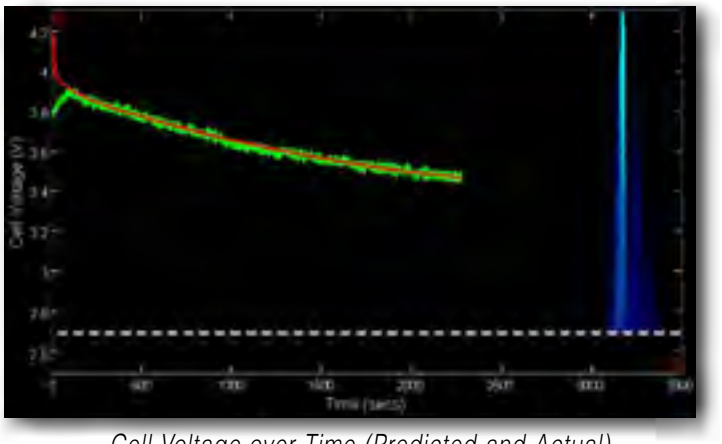
technology opportunity

Model-Based Prognostics For Batteries

Prognostics and Estimation of Remaining Useful Life of Energy Storage Devices

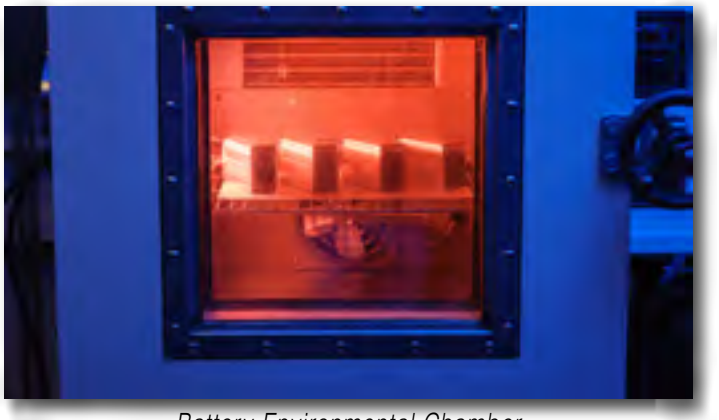
Battery-powered devices have become ubiquitous in the modern world, from tiny headsets to cameras, cell phones and laptops to hybrid and electric vehicles. They form a core component of many machines and are often times critical to the well-being and functional capabilities of an overall system. Failure of a battery could lead to reduced performance, operational impairment and even catastrophic failure, thus motivating the study of Battery Health Management. Effective battery health monitoring (BHM) technologies are needed to ensure that battery operation is optimal, and if not, that it stays within design limits and warnings are provided to operators or automated actions are taken to mitigate damage when these limits are exceeded. BHM technologies protect the asset's batteries from degradation due to non-optimal usage, and ensure viable levels of system availability, reliability and sustainability in the presence of degraded batteries.

Prediction of the remaining useful life (RUL) of a system's component is at the center of effectively managing a system's health. This invention provides as many as eight different prognostic modes for estimating the state of charge, state of life, end of discharge, and/or end of life of a battery. These estimates help in making predictions of the remaining useful life for individual discharge cycles as well as for cycle life.



Cell Voltage over Time (Predicted and Actual)

The above figure provides a graph of the cell voltage of a lithium-ion battery. The green line represents the empirical measurements of the cell voltage. The red line represents the predicted cell voltage versus time obtained with the simulation model. The vertical blue line represents the predicted time estimates for the battery failure.



Battery Environmental Chamber

Benefits

- Provides enhanced health management routines for batteries
- Provides mathematical rigorous reasoning framework for better understanding, representation, manipulation, and management of the various sources of uncertainty inherent in prognostics of battery remaining useful life
- Allows a variety of models to be accommodated
- Produces remaining useful life PDF-formatted reports as output – a more individualized representation of the real condition than statistics such as mean time between failure of battery health
- Provides accurate gauge for remaining electrical charge and for trade-offs in long-term durability and short-term usage needs

Applications

- Commercial concerns using batteries as the primary (or backup) power source for their product
- Commercial concerns pursuing research and development for Prognostic Health Management/ Condition-Based Maintenance
- Manufacturers of primarily battery-powered vehicles for land, air, and water
- Companies developing software products for system health management

Technology Detail

This invention relates to the prediction of the remaining useful life of an object in use. It develops a mathematical model to describe battery behavior during individual discharge cycles as well as over its cycle life. The models used to estimate the remaining useful life of batteries are linked to the internal electro-chemical processes of the battery. The effects of temperature and load have been incorporated into the models. Model validation studies were conducted using data from a series of battery cycling experiments at various thermal and electrical loading conditions. Subsequently, the model has been used in a Particle Filtering framework to make probabilistic predictions of remaining useful life for individual discharge cycles as well as for cycle life.

Patents

This technology has been patented (U.S. Patent 8,332,342).
Reference: ARC-16320-1.

Licensing and Partnering Opportunities

NASA's Technology Transfer Program seeks to transfer this technology out of NASA's space program to benefit U.S. industry. NASA invites companies to inquire about licensing possibilities for this technology for commercial applications.

For More Information
If you would like more information about this technology, please contact:

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You can also visit our website at http://technology.arc.nasa.gov.